"MAGNETIC SEPARATOR WITH FERRITE AND RARE EARTH PERMANENT MAGNETS"

The present invention relates to magnetic separators with permanent magnets, and in particular to a separator provided with permanent magnets made of ferrite and rare earth elements, capable of enhancing and optimizing the attraction effect of variably ferromagnetic materials. The present application specifically refers to a pulley separator, but it is clear that what is said also applies to other types of magnetic separators (drums, plates, belts, etc.) which can be provided with the permanent magnets described herein.

It is known that magnetic separators are used in all those applications where it is necessary to attract and separate ferromagnetic materials of any shape and size from mixed material. The attractive capacity of the separator depends both on the magnetic field that it can generate (strength and gradient), and on the intrinsic induction of the object to be separated as it results from its shape factor (e.g. the sphere has the worst shape factor) and from its degree of permeability.

Attractive circuits (i.e. permanent magnets) made of ceramic materials such as barium ferrite, and even better strontium ferrite, are known since more than forty years. These magnets have a medium intrinsic and residual magnetic energy, and are capable of attracting within a certain distance ferromagnetic materials with high shape factor and/or medium-high permeability.

Other attractive circuits made of sintered materials with high intrinsic residual magnetic energy, known as rare earth elements (samarium-cobalt, iron-boron-neodymium), have been in use more recently, in the last 15-20 years. These magnets can attract within a relatively short distance, yet with great effectiveness, even materials with low shape factor and/or medium-low and very low permeability. Their effectiveness is however concentrated within few tens of millimeters.

Therefore the object of the present invention is to provide a magnetic separator which overcomes the limitations of known separators. This object is achieved by means of a separator in which each magnetic pole is made up of ferrite magnets in the bottom portion in contact with the ferromagnetic member for

the circuit connection between the poles, and of rare earth magnets in the top portion that represents the entrance/exit surface of the magnetic flux lines.

The main advantage is that of combining the magnetic characteristics of the two types of permanent magnets described above (ferrite and rare earth) so as to make them complementary and thus enhance the attractive effectiveness both for ferromagnetic materials with high or low shape factor, and for materials with high or low and sometimes very low permeability.

In this way the attractive range of these magnets is greatly amplified and the separator can operate with a productivity almost twice as much as a similar separator with rare earth magnets, and with a quality of separation very high with respect to a medium-low effectiveness of a similar separator with ferrite magnets.

Another significant advantage comes from the very simple structure of said attractive circuits, which result easy to manufacture and to apply to any kind of separator.

Further advantages and characteristics of the separator according to the present invention will be clear to those skilled in the art from the following detailed description of an embodiment thereof, with reference to the annexed drawings wherein:

Fig.1 is a cross-sectional view of a prior art pulley separator with ferrite magnets;

Fig.2 is a cross-sectional view of a prior art pulley separator with rare earth magnets;

Fig.3 is a cross-sectional view of a prior art pulley separator with ferrite and rare earth magnets according to the present invention;

Fig.4 is an enlarged diagrammatic view showing in detail the structure of an attractive circuit according to the present invention;

Fig.5 is a partial plan view of a first possible arrangement of the polarities for the separator of fig.3; and

Fig.6 is a partial plan view of a second possible arrangement of the polarities for the separator of fig.3.

With reference to fig.1, there is seen that a permanent magnet pulley 1 essentially consists of a ferromagnetic cylinder 2 around which there are applied

ferrite magnetic masses 3A, said cylinder 2 being enclosed by a protective casing 4 of non-magnetic material (e.g. stainless steel) that is preferably filled with a blocking resin 5. This assembly is secured through end flanges onto a driving or idle shaft, so that it can be preferably used as driving roller for a conveyor 6 provided with slats 7 on which the material 8 to be treated is drawn.

The dimension H1 indicates the effective working height with respect to the layer of material 8 to be treated, and an indicative value for a pulley of 400 mm in diameter is H1 ≅ 80-90 mm for ferromagnetic parts with medium-high shape factor and good permeability.

In fig.2 there is illustrated a pulley similar in shape and size to the one above, with magnetic masses 3B of rare earth elements, in which the working height H2 is 40-50 mm for ferromagnetic parts with medium-low shape factor and low permeability, and within 30 mm of distance from the active surface for parts with very low permeability.

In fig.3 there is illustrated a pulley similar in shape and size to the ones above, with mixed magnetic masses 3C according to the present invention, where for merely exemplificative purposes there are used in particular in each pole two ferrite blocks 12 about 25 mm high located in contact with the ferromagnetic cylinder 2 and one rare earth block 13 also about 25 mm high placed on top of and in contact with the ferrite blocks 12 and close to the non-magnetic casing 4.

In the detail of fig.4 there is illustrated a permanent magnet circuit according to the present invention including at least two poles 3C North-South each of which is made up in the bottom portion, in contact with the ferromagnetic cylinder 2 for the circuit connection between the poles, of ferrite magnets 12 (preferably strontium ferrite) and in the top portion that represents the exit surface 14 of the magnetic flux lines 15 when North pole, or entrance surface 16 when South pole, of rare earth magnets 13 (preferably iron-boron-neodymium) capable of increasing the values of the magnetic field and in particular of the magnetic field gradient.

In figs.5 and 6 there are illustrated for exemplificative purposes two possible polarities arrangements in the longitudinal direction for magnetic pulleys; in particular, fig.5 shows a chequered arrangement of the various North-South magnetic poles whereas fig.6 shows the arrangement with longitudinal alternate

rows of North-South polarities.

For a comparison between the indicative field and field gradient values that can be obtained in the three separators above, reference is made to the following table. In this table, D is the distance at which the magnetic field is measured, while G is the field gradient measured over the specified distance interval.

DISTANCE AND GRADIENT	FERRITE	RARE EARTH	FERRITE+ RARE EARTH
D=10 mm (Öe)	1015	2000	2500
G over 10-20 mm (Öe/cm)	245	820	900
D=20 mm (Öe)	770	1180	1600
G over 20-30 mm (Öe/cm)	150	510	500
D=30 mm (Öe)	620	670	1100
G over 30-40 mm (Öe/cm)	120	310	300
D=40 mm (Öe)	500	360	800
G over 40-50 mm (Öe/cm)	90	160	240
D=50 mm (Öe)	410	200	560
G over 50-60 mm (Öe/cm)	60	-	160
D=60 mm (Öe)	350	-	400
G over 60-70 mm (Öe/cm)	50	-	120
D=70 mm (Öe)	300	-	280
G over 70-80 mm (Öe/cm)	50	-	80
D=80 mm (Öe)	250	-	200
G over 80-90 mm (Öe/cm)	40	-	50
D=90 mm (Öe)	210	-	150

This novel type of attractive circuit applied, for a comparative example, to the above-mentioned pulley thus surprisingly allows to enhance the characteristics of the two types of magnets at the distances where they are less effective, yet retaining their advantageous characteristics in the zones where they better work individually.

This results clearly from the possibility of having a better performance in the zone beyond 50 mm of distance from the active surface, thanks to the higher gradient, with respect to the ferrite magnet pulley that has trouble with poorly magnetizable materials; and similarly this results from the possibility of having a significantly improved average performance in the zone within 50 mm, thanks to the stronger field, with respect to the similar rare earth magnet pulley.

It is clear that the above-described and illustrated embodiment of the magnetic separator according to the invention is just an example susceptible of various modifications. In particular, the ratio between the effective magnetic length of ferrite and rare earth elements in each pole may be different from the above-illustrated 2:1 ratio, indicatively between 1:1 and 3:1, and obviously the number, shape and arrangement of the magnetic poles can be freely changed according to the needs.